on the sediment transport & morphodynamics in LPR

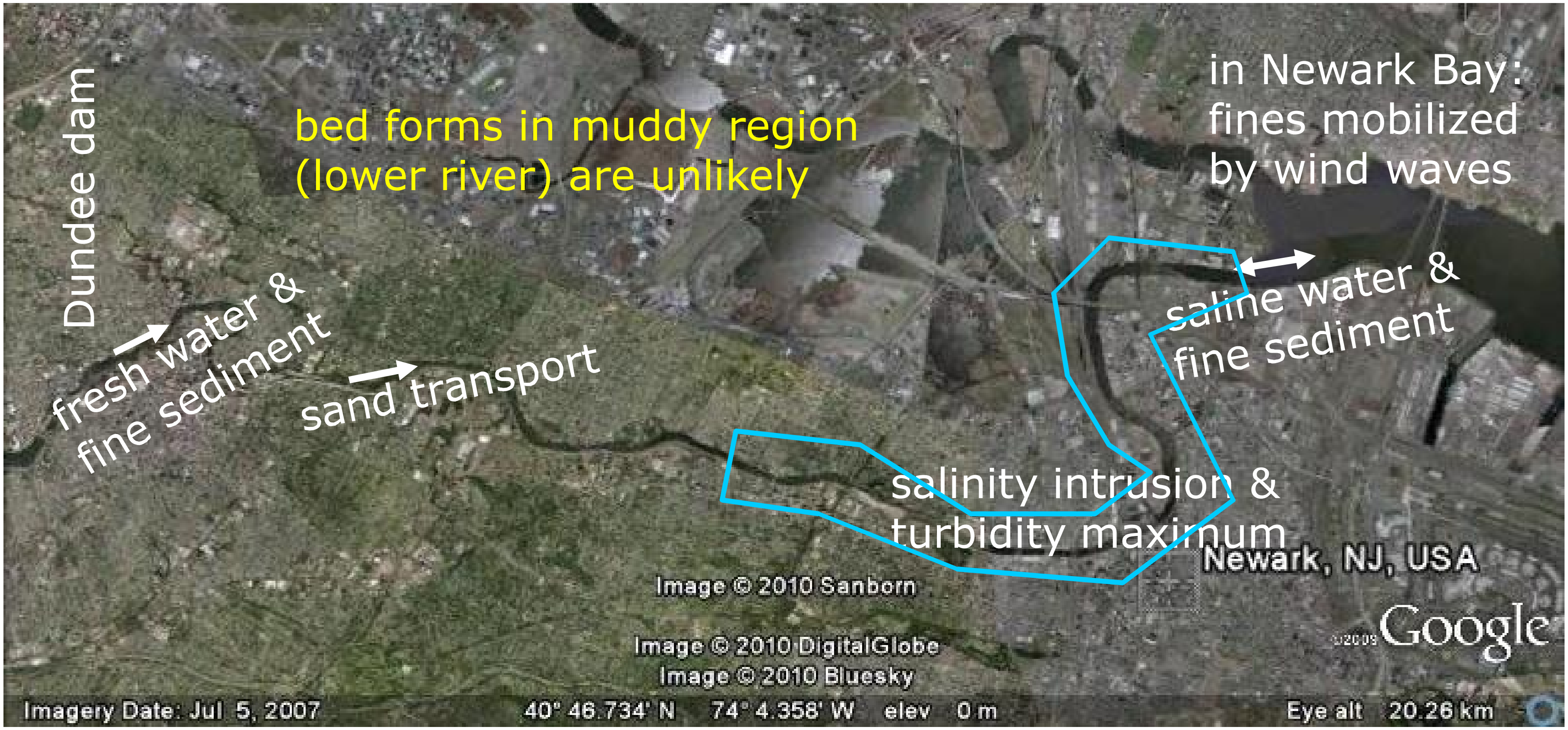
meeting February 4, 2010
Newark

contents

- current response of river to hydrodynamic forcing (do we understand sediment transport patterns?)
- historic response of river to hydrodynamic forcing (do we understand sedimentary patterns?)

part of this work has been presented before,
and many earlier result sheets are not given again

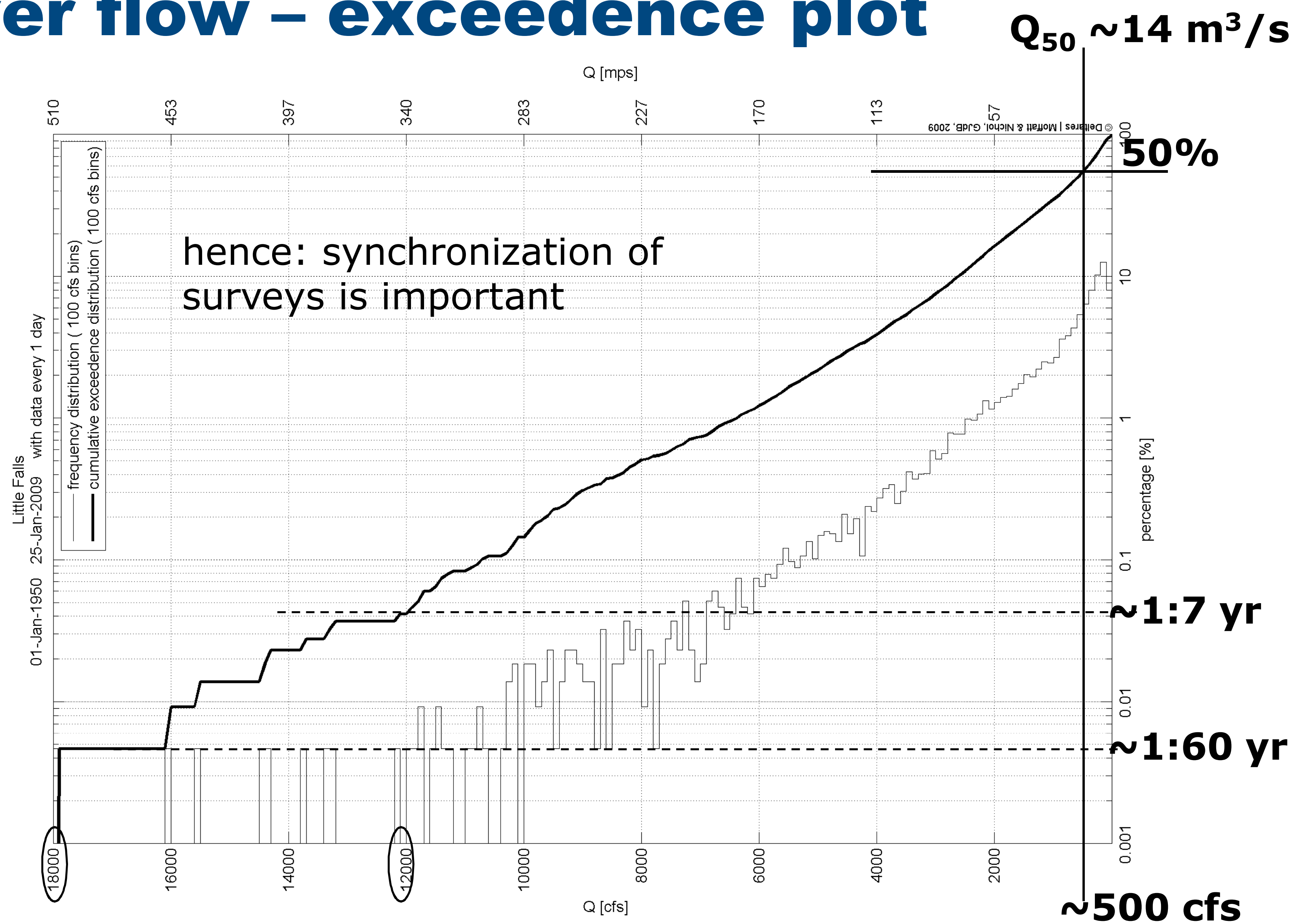
general features of LPR



Sediments washed out of the LPR settle in Newark Bay. They may be remobilized by wind waves and return into LPR by gravitational circulation **BUT together with Newark Bay sediments, hence mixed**

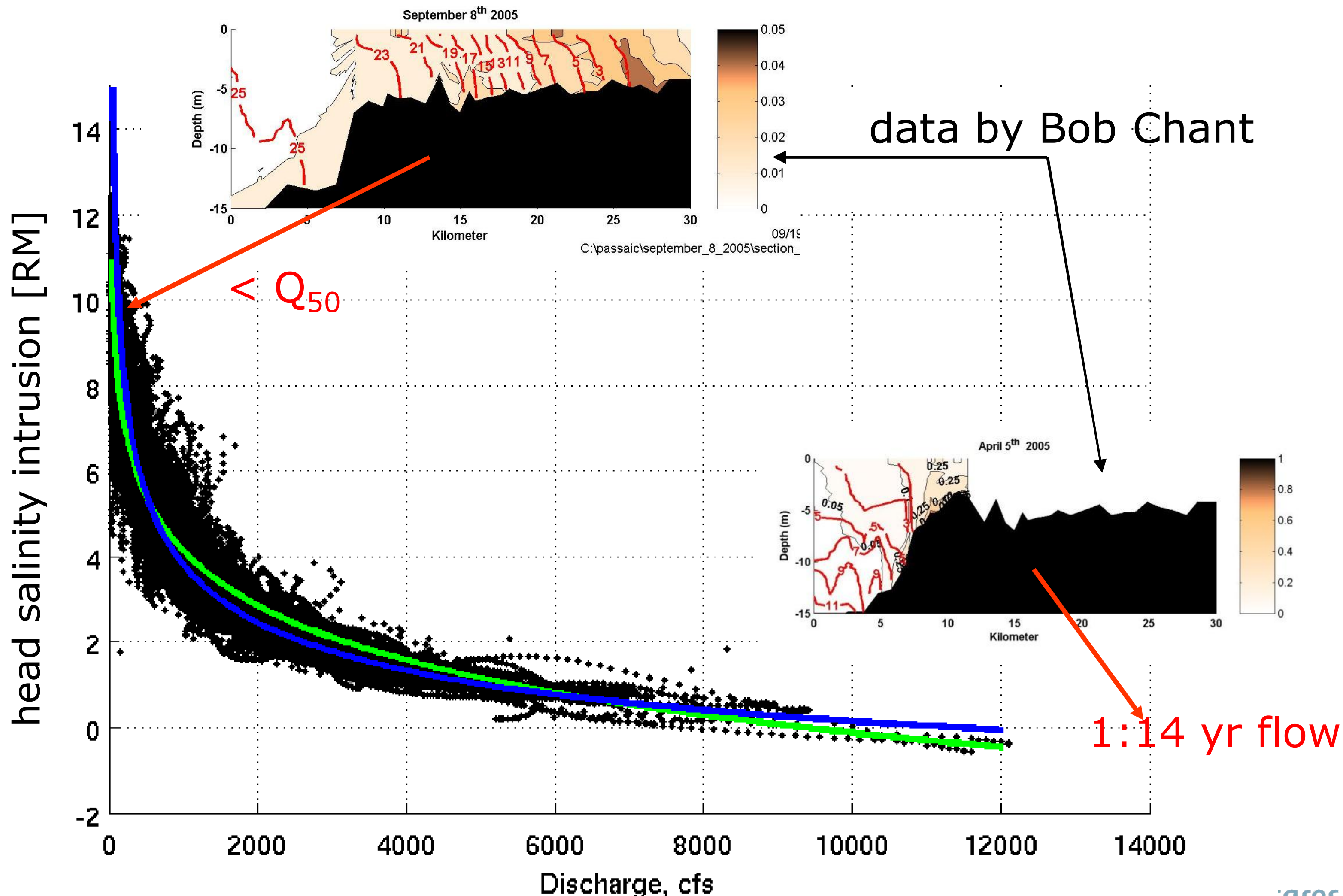
Deltares

river flow – exceedence plot

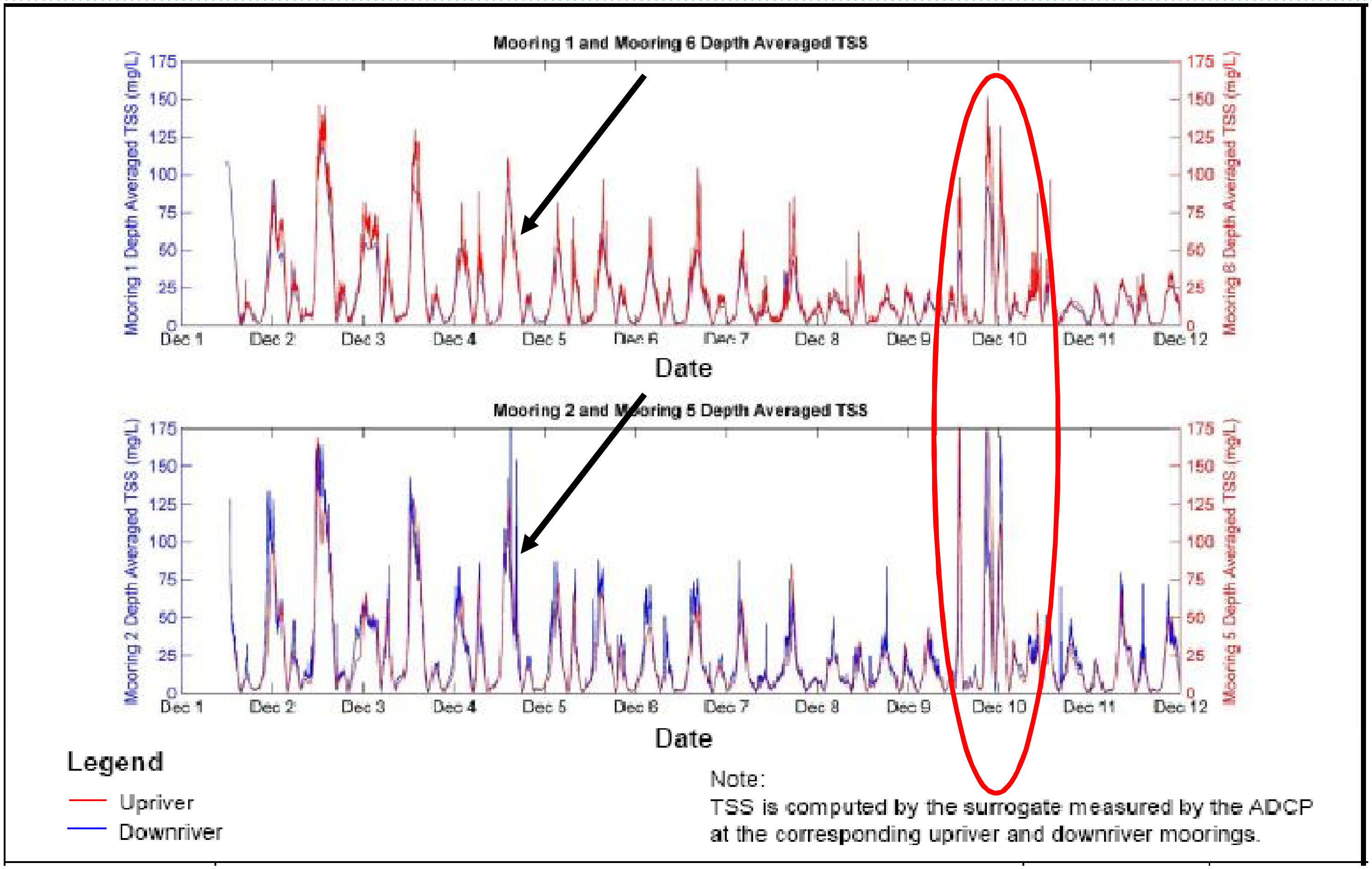


hence: synchronization of surveys is important

salinity and river flow (from model)

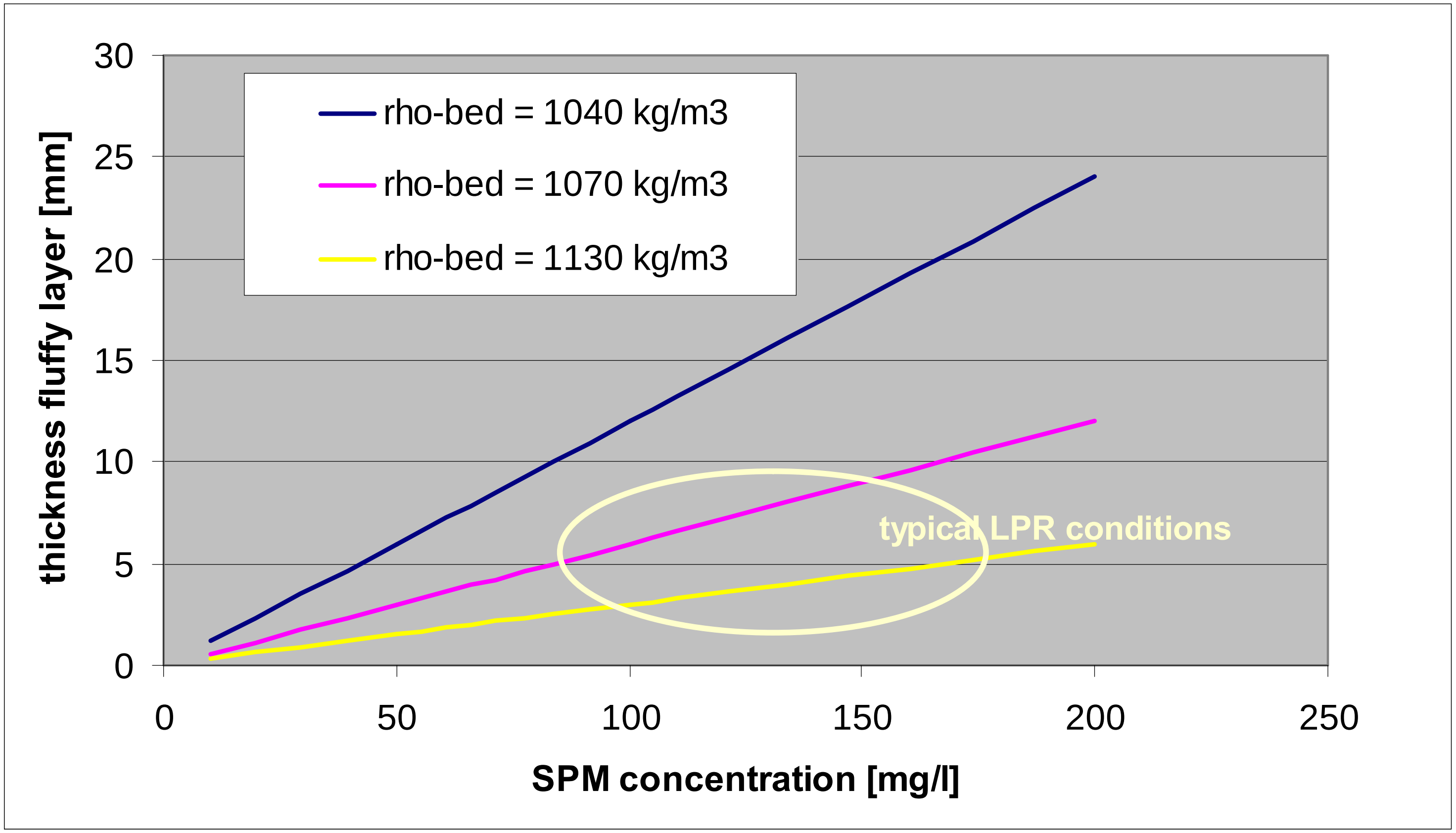


typical SPM concentrations (pilot dredging Dec 2005)



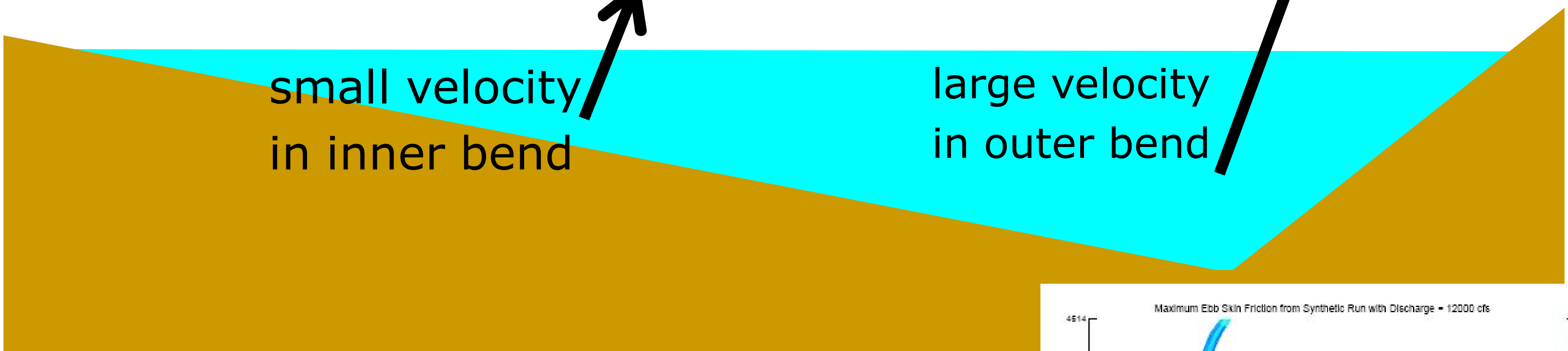
note large sedimentation rate around slack water, and flood concentrations generally larger than ebb concentrations

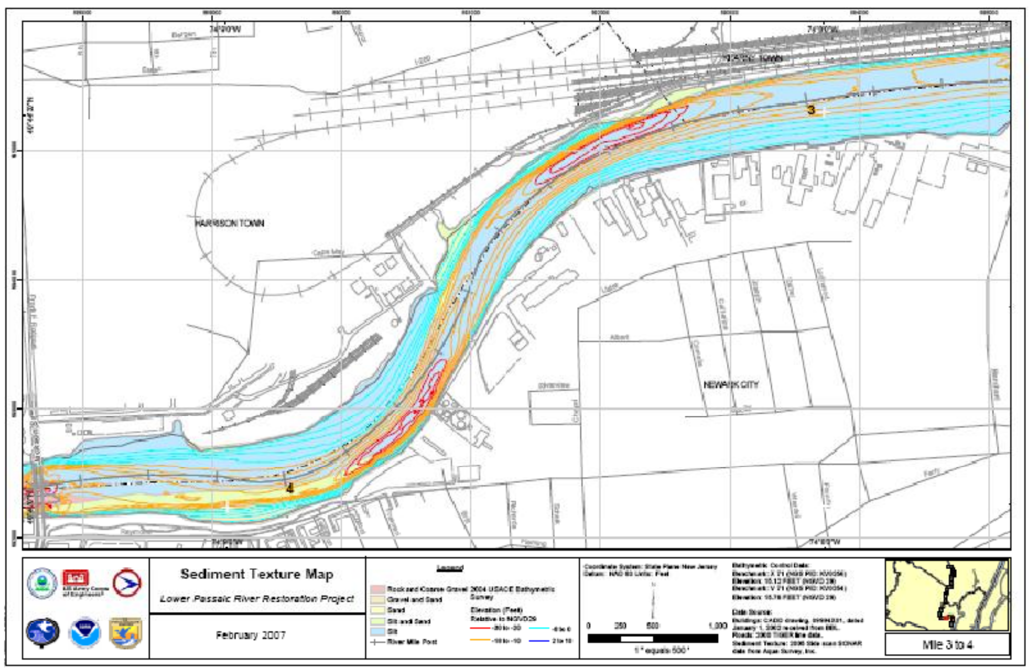
thickness of fluffy layer

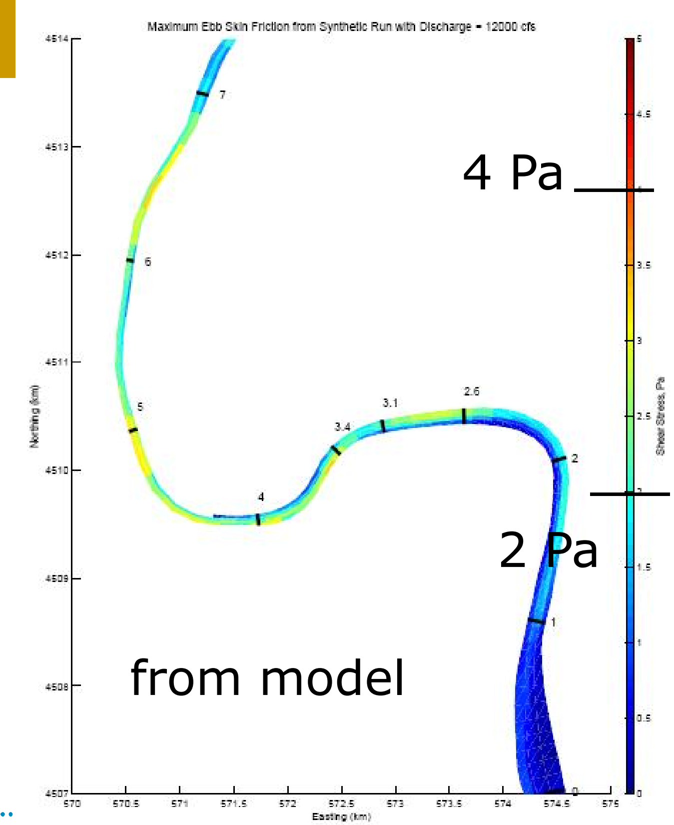


most of the time:
fine sediments settle around slack water, forming a thin fluffy layer, which is resupended during accelerating tide

some basic river hydraulics



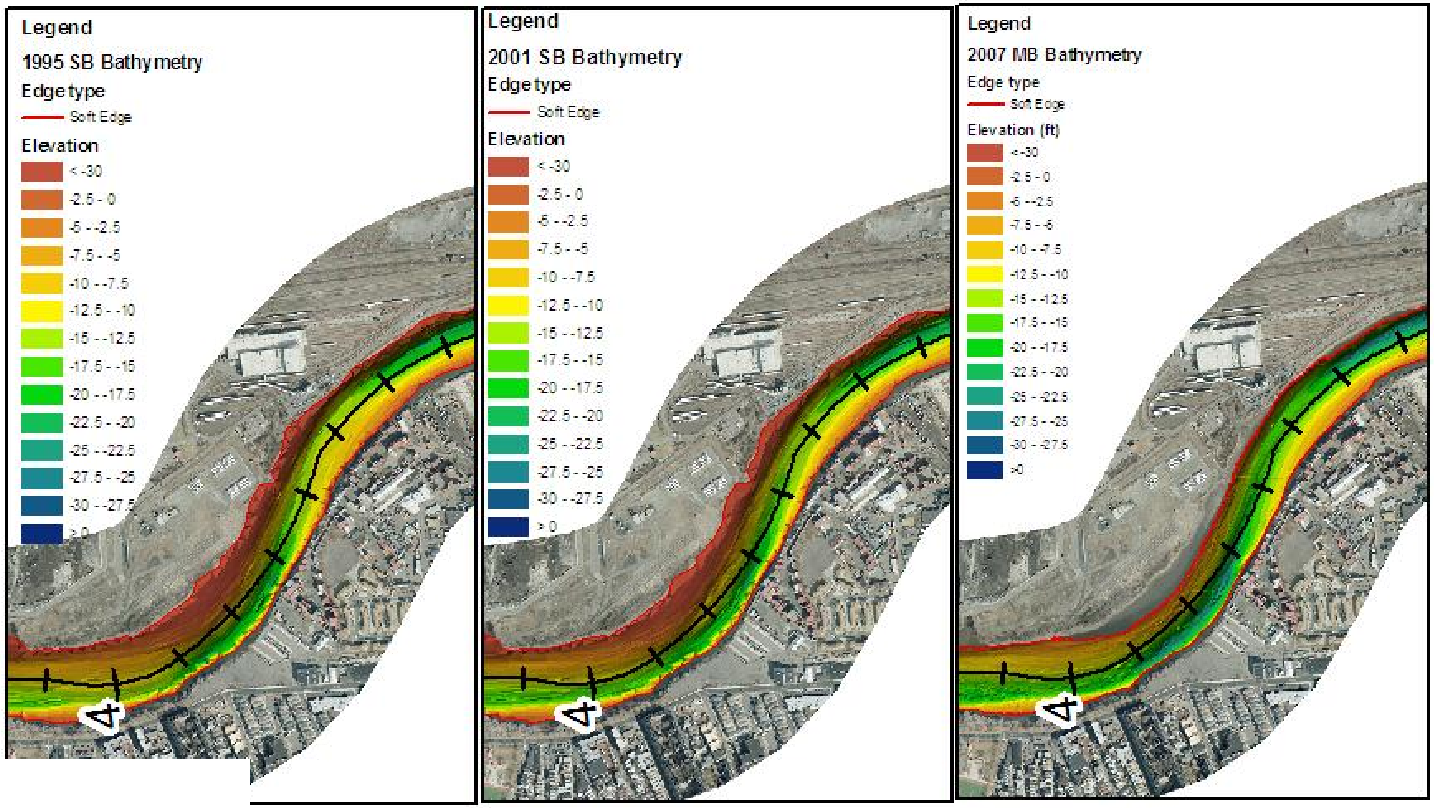


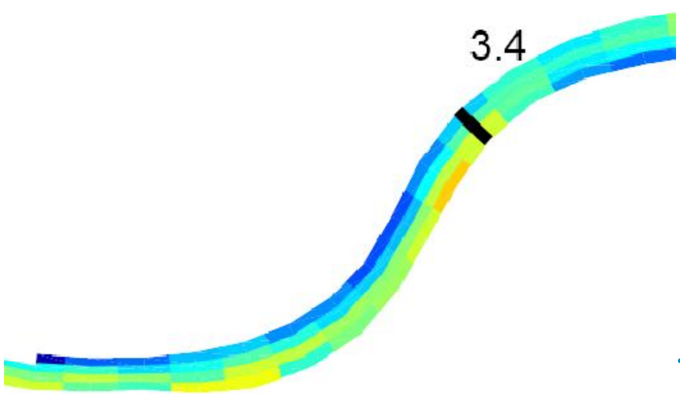


response to river floods

- under normal conditions: tidal exchange of fine sediment between fluffy layer (< 1cm) and water column,
- and slow net sedimentation rate,
- during river floods, flow velocities and bed shear stresses increase considerably, which may result in local scour (depending on strength of sediments themselves)
- if occurs, scour rates are relatively large,
- so time scales of scour and sedimentation are largely different (affects comparison of bathymetrical maps)

measured bathymetries

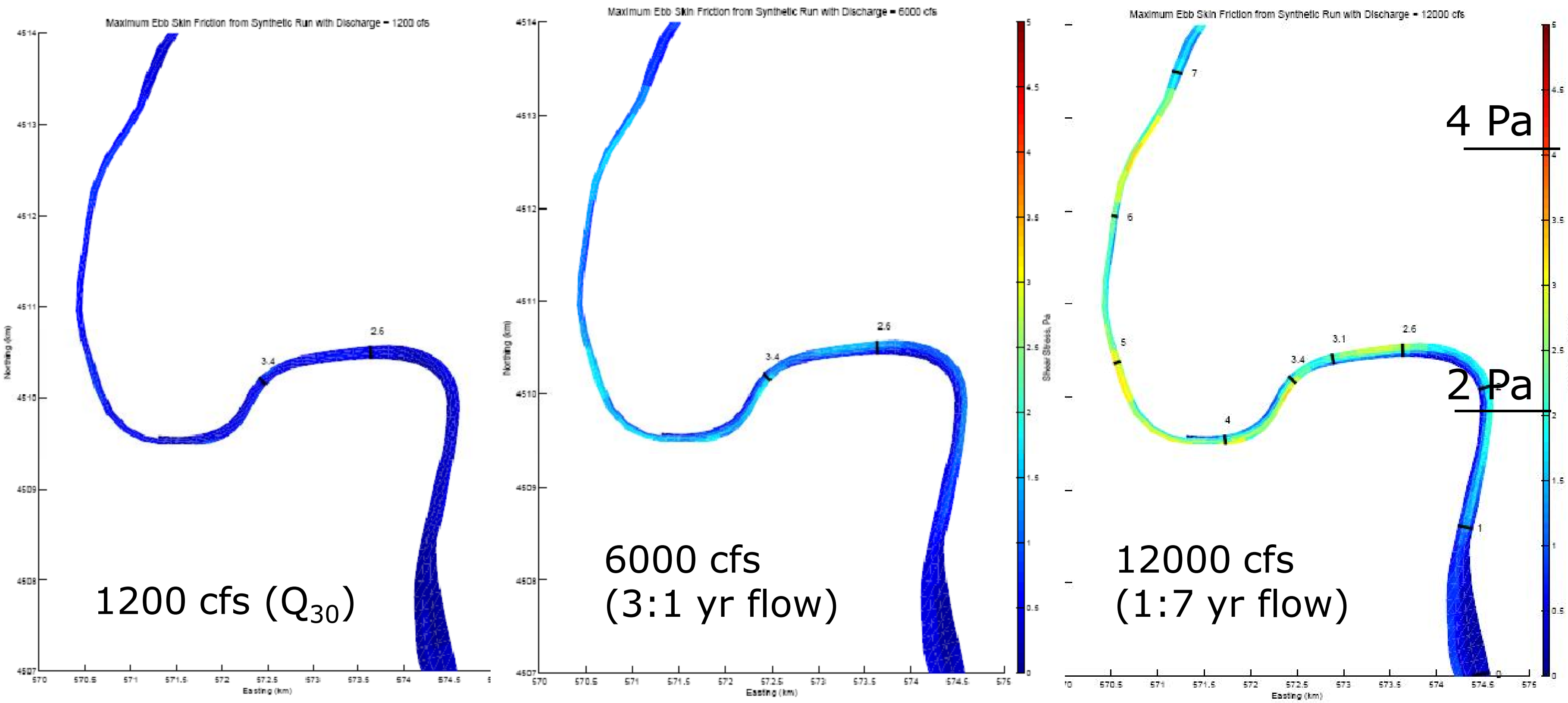




larger depths coincide with locations of computed high stresses

computed maximal ebb skin friction

the model shows us increasing bed shear stresses with increasing river flow, in particular in outer bends



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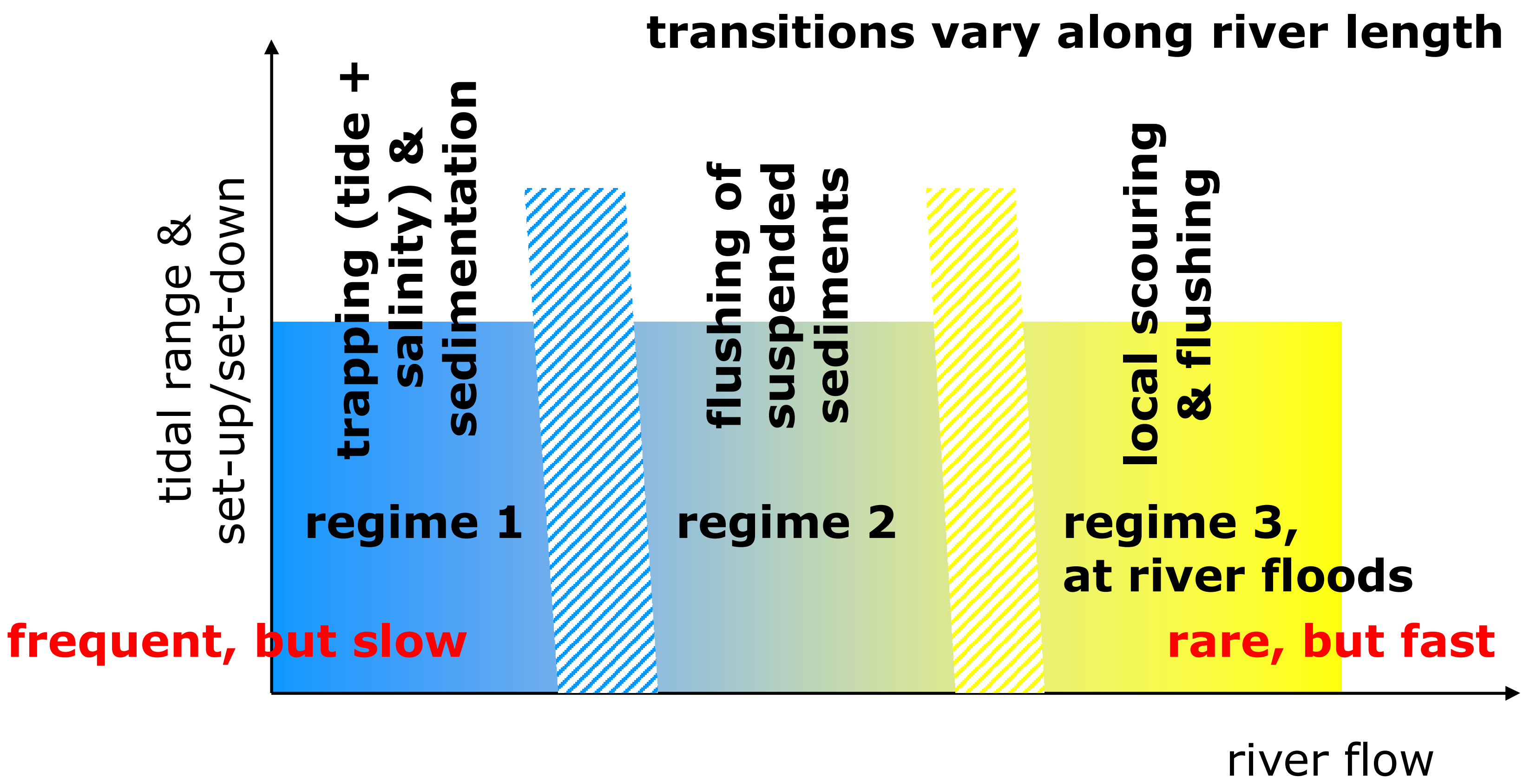
hydro-sedimentological regimes LPR



this is a common picture for rivers elsewhere in the world

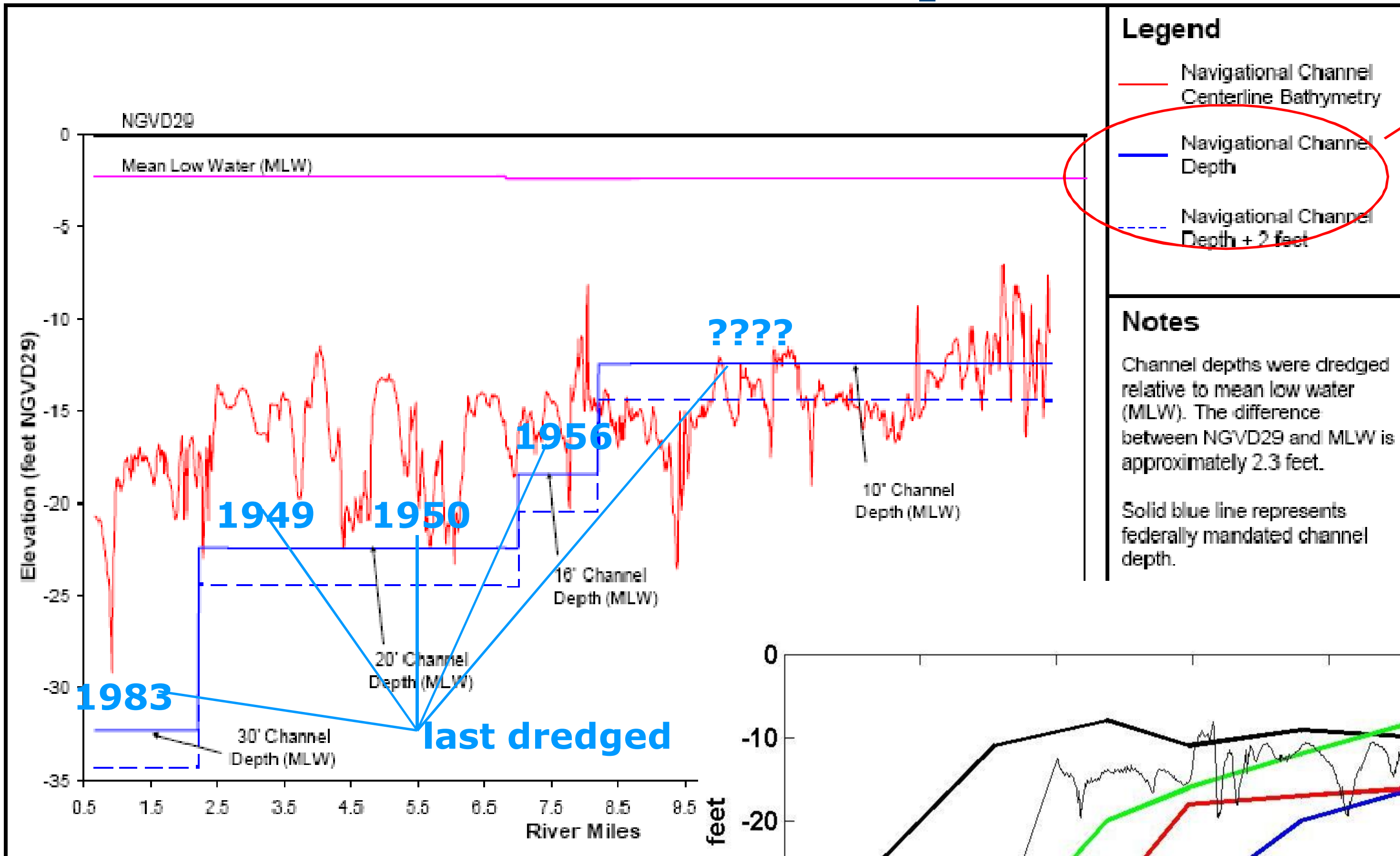
LPR long-term development

- is this conceptual picture consistent with information on the LPR cores?
- can we understand the observed (from cores) distribution of legacy sediments?

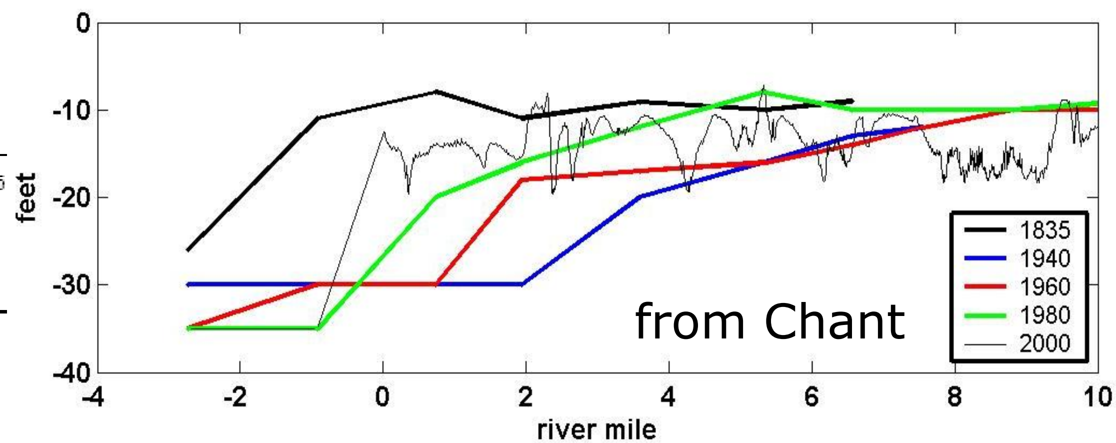
to understand, we need to analyze the historic development of the river

historic channel depths

historical design depths



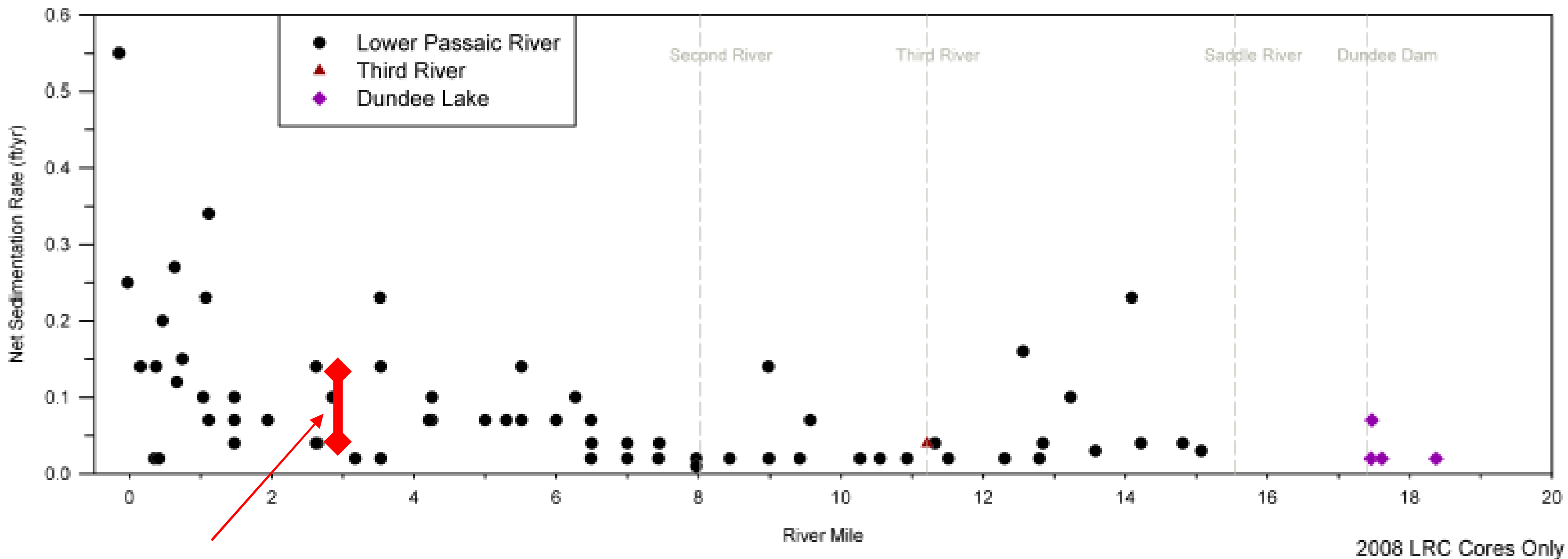
after Conc. Site model Report



from Chant

net infill up to today

long-term averaged net sedimentation rate from Cs137 and Pb210 profiles



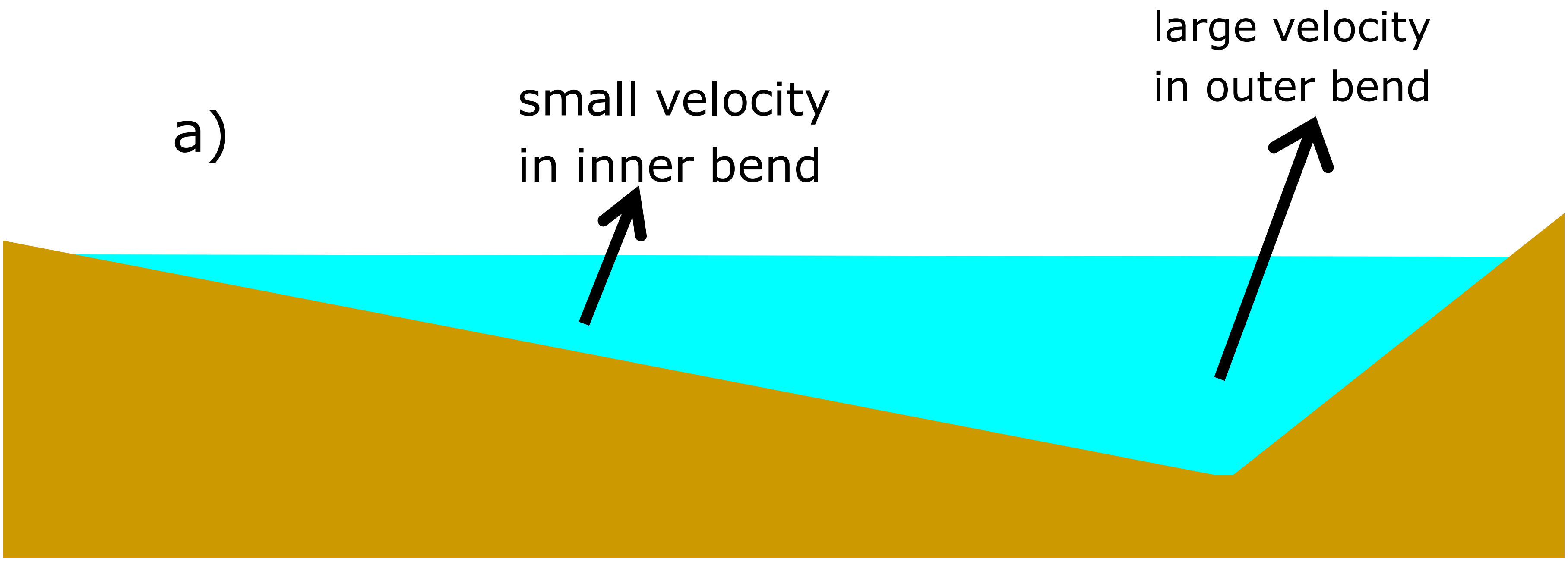
gross siltation rate during pilot dredging experiment (Dec 2005); most likely from accumulation and consolidation of fluffy layer

rate is consistent with historic observations

morphodynamic response (1)

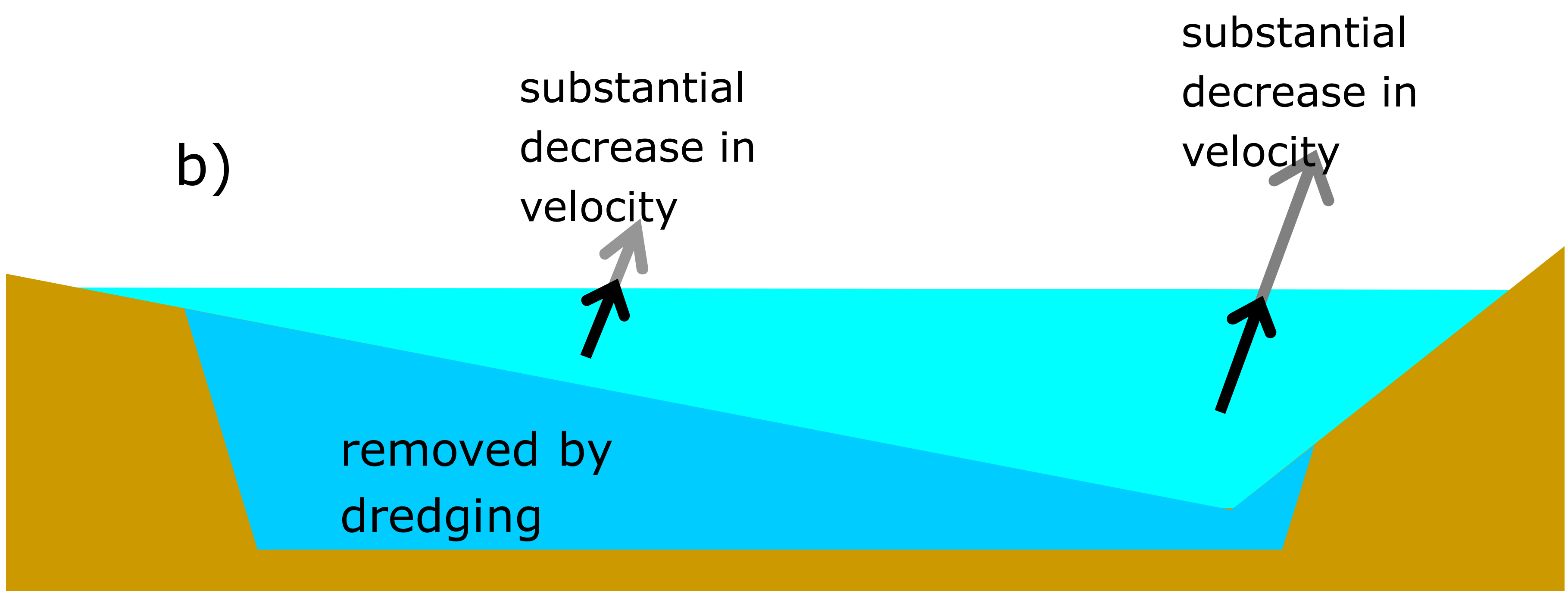
- in post-dredging period, rivers fills in slowly with fine sediments from upriver (Dundee Dam) and Newark Bay
- during infill period, contaminants were released which adhered to these sediments – we refer to these therefore as the legacy sediments
- question: how did infill take place?

morphodynamic post-dredging response (1)



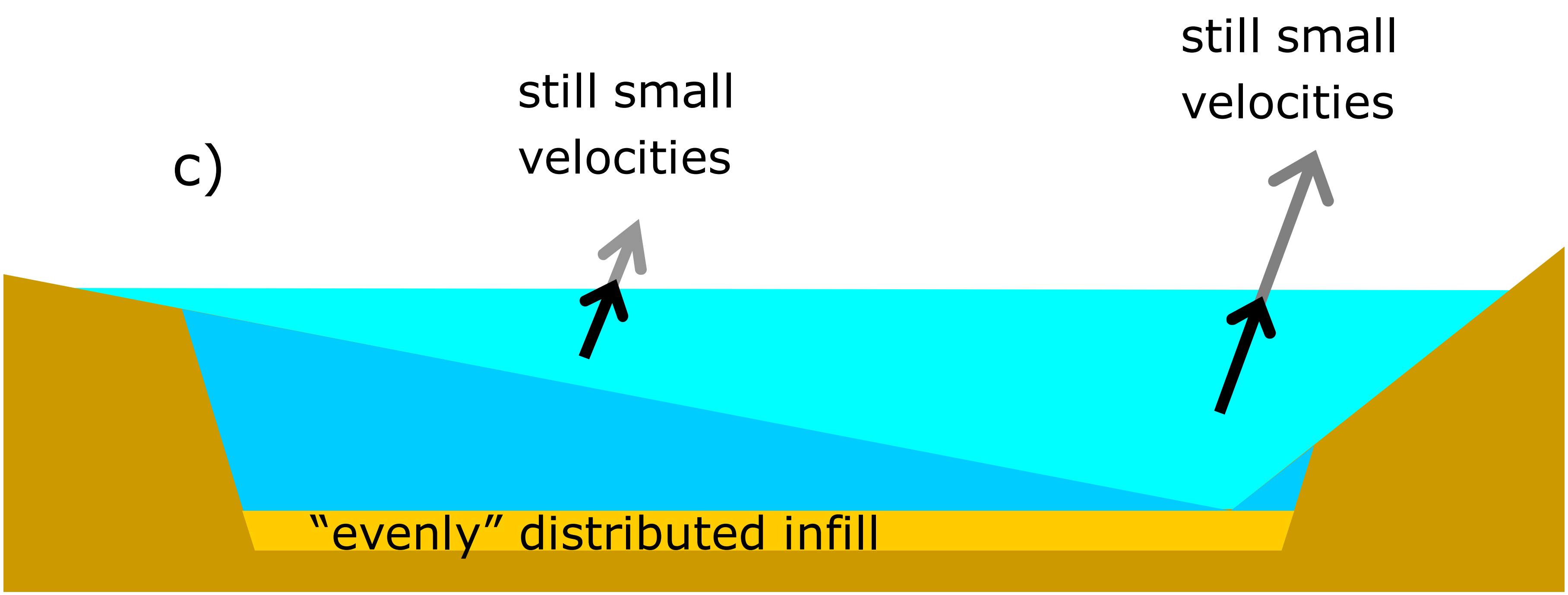
because of inertia and secondary currents,
the outer bend of a river in morphodynamic
equilibrium is always deeper than the inner bend

morphodynamic post-dredging response (2)



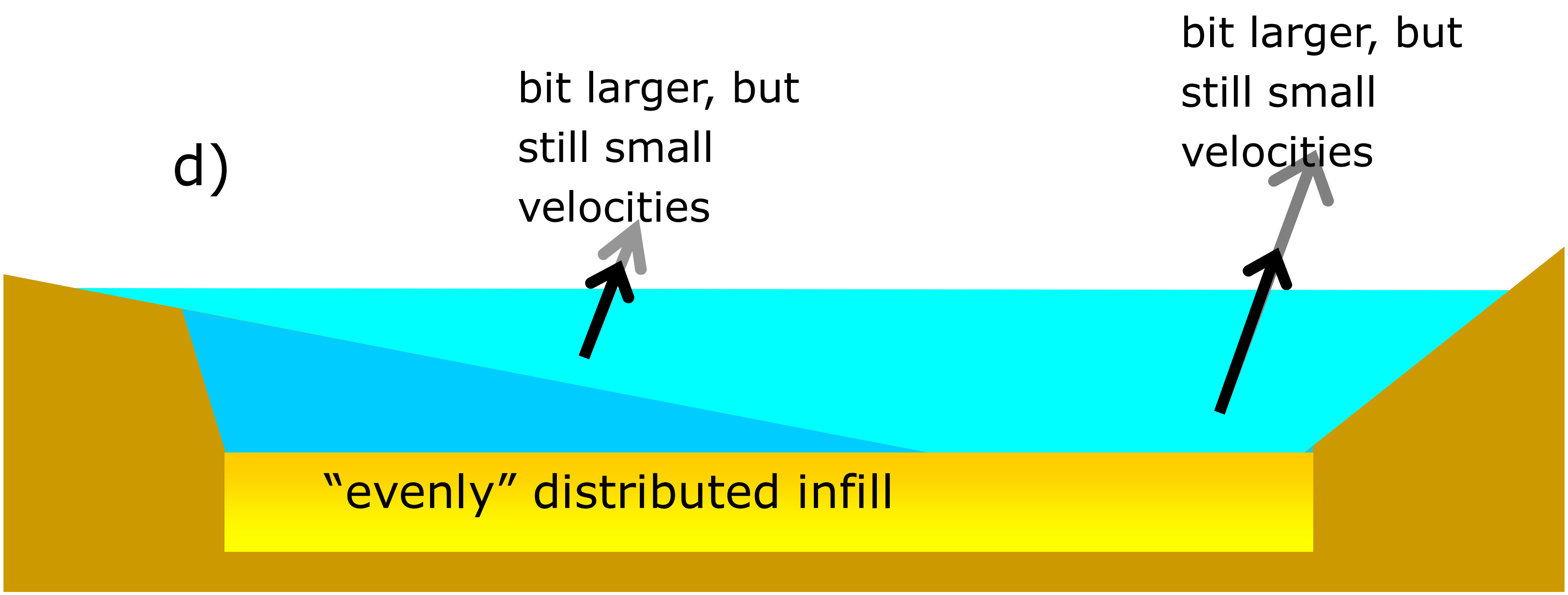
after deepening river conditions
cross section increases considerably, and
flow velocities throughout cross section decrease

morphodynamic post-dredging response (3)



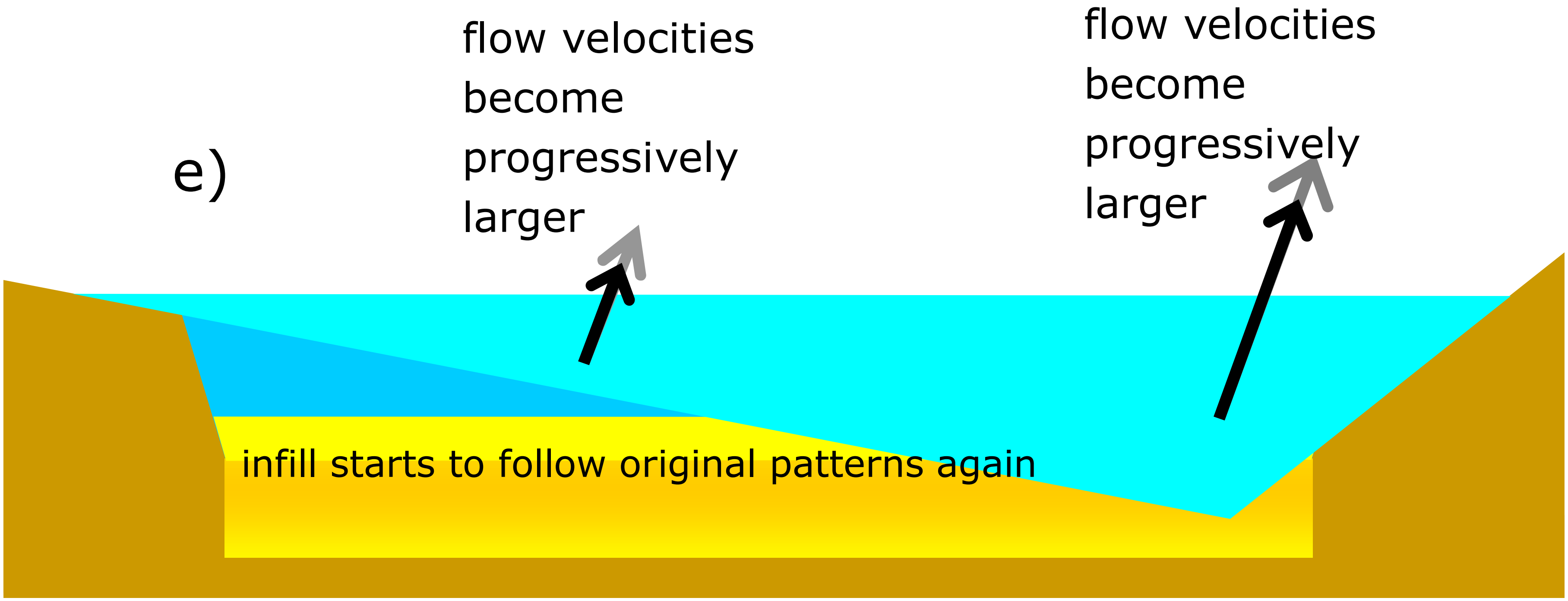
after dredging stopped in 1950, infilling started; initially sedimentation is more or less evenly distributed as flow velocities are small throughout cross section

morphodynamic post-dredging response (4)



later, younger sediments covered the earlier deposits; infill is still more or less evenly distributed as flow velocities are still fairly small

morphodynamic post-dredging response (5)



instead of even infill over the cross section, the classical deep outer bend configuration is restored: this implies near-surface legacy sediment in the outer bend.

picture becomes slightly more complicated in saline part of the river

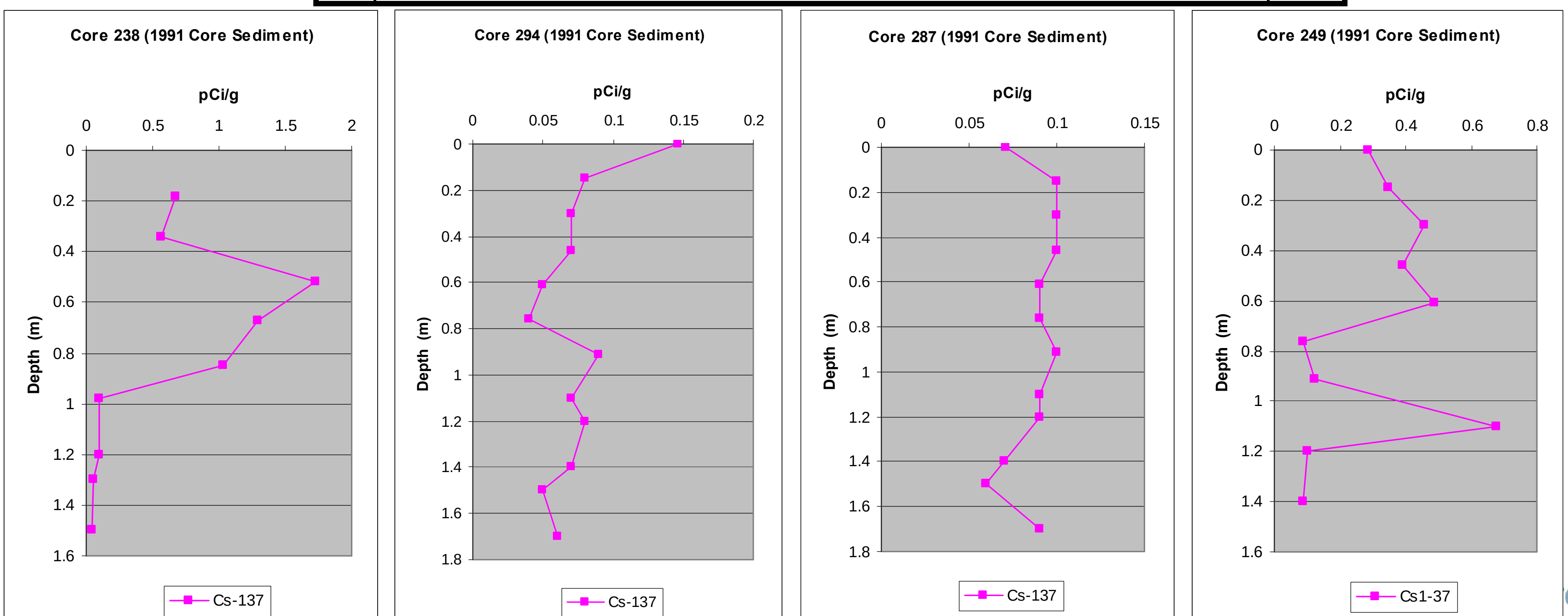
summary & corroboration

- in post-dredging infills, we expect:
  - legacy sediments buried in inner bends,
  - legacy sediments close to bed surface in outer bends.

- this can be tested against observations – we use 1995 Cs^{137} data – see also Aecom analysis 2008 data

TSI 1995 dataset of cores

TSI 1995 dataset of 93 cores		
a	submerged maximum of Cs-137	57
b	maximum of Cs-137 at the bed surface	7
c	Cs-137 maximum < 0.1 pCi/g	15
d	erratic cores	11
	no core (only surface values)	3
	total	93

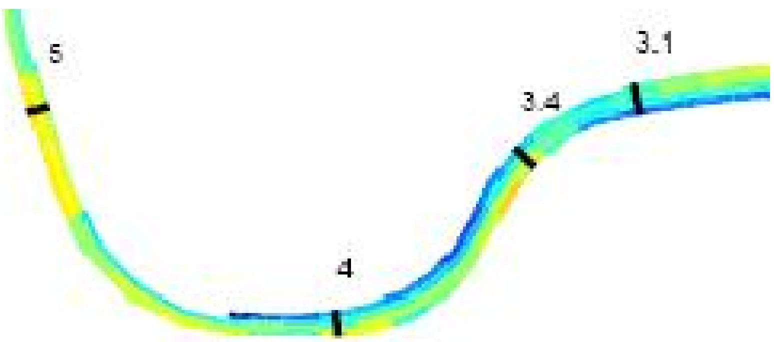


TSI 1995 dataset of cores - summary

Cores with top-of-core Cs^{137} conc. > 0.5 pCi/g

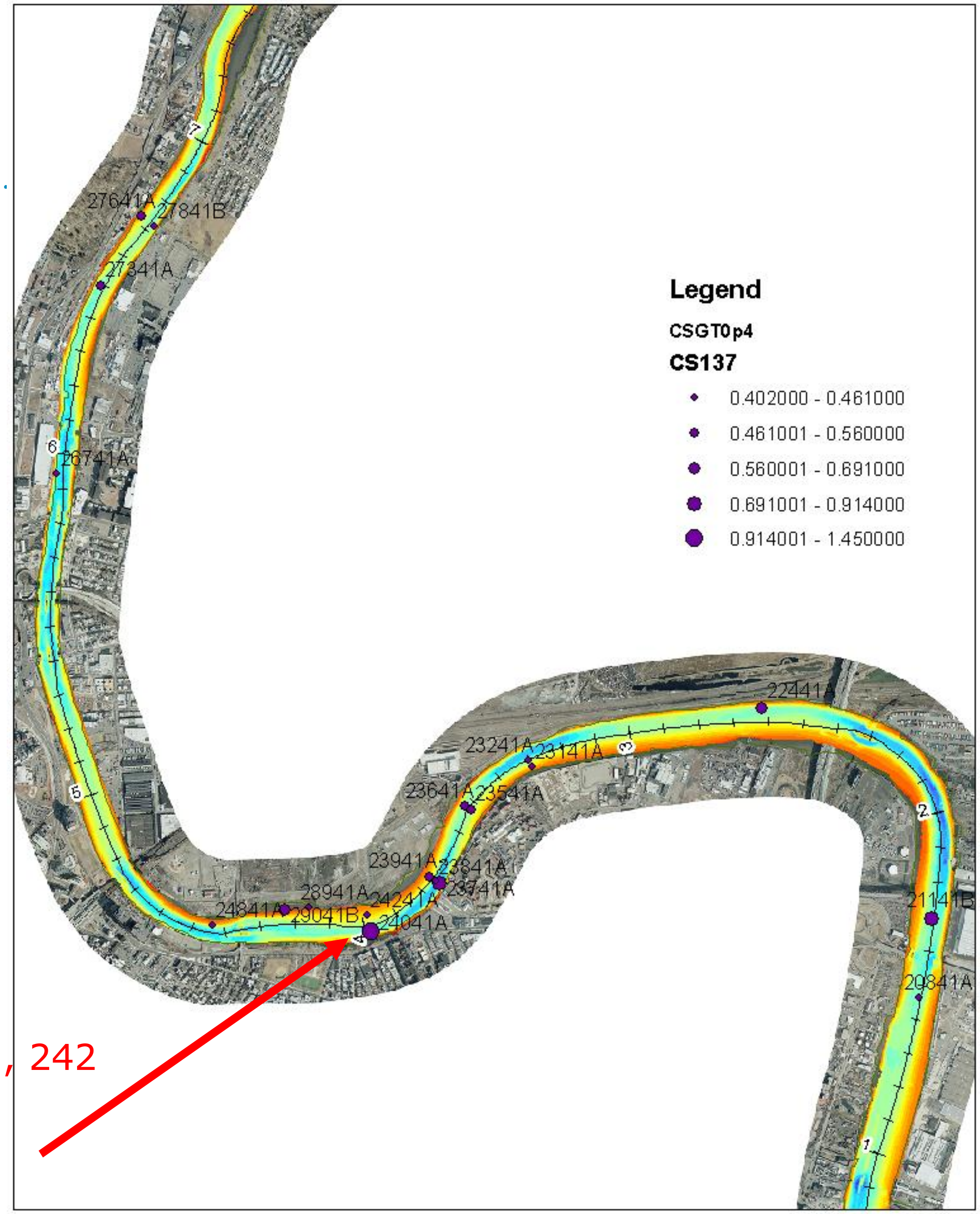
core number	river mile	Cs-137 top of core concentration (pCi/g)	features
213	1.94	0.89	anomaly – inner bend (affected by 1983 dredging?)
224	2.62	0.69	deep outer bend and large τ
236	3.53	0.52	~ flat bed and large τ
237	3.75	0.91	deep outer bend and large τ
240	4.00	1.45	deep outer bend and large τ
273	6.50	0.56	deep outer bend but small τ, (too low model resolution)
278	6.75	0.51	deep outer bend and large τ

location of the cores in relation to the river bends



computed skin friction

cores 240, 241, 242



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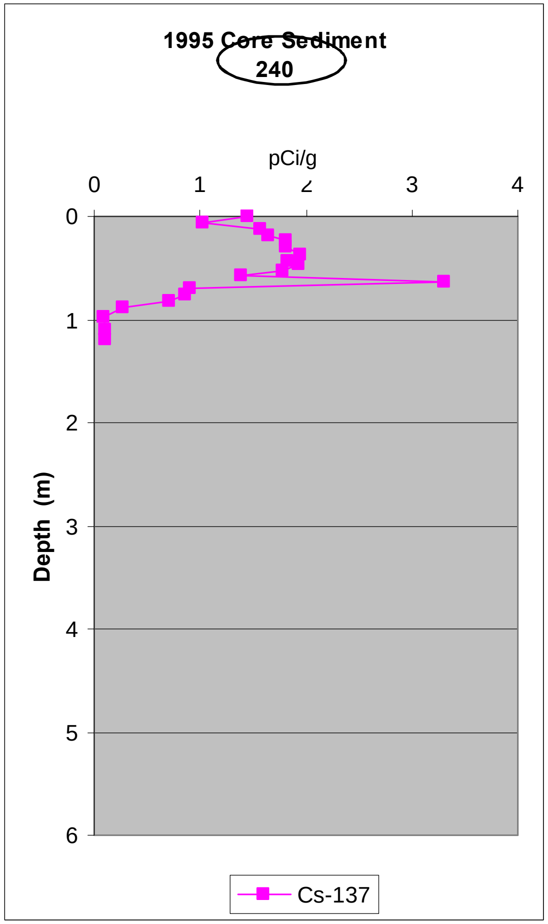
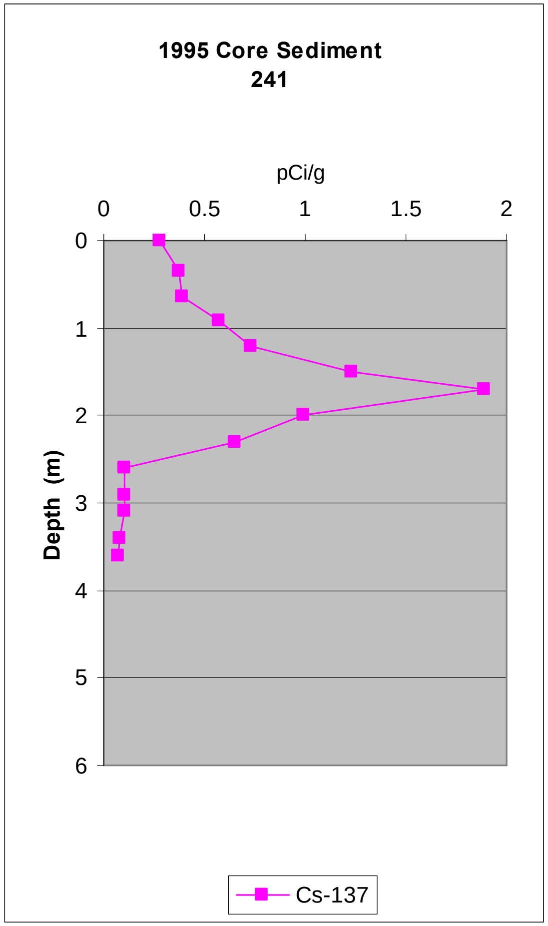
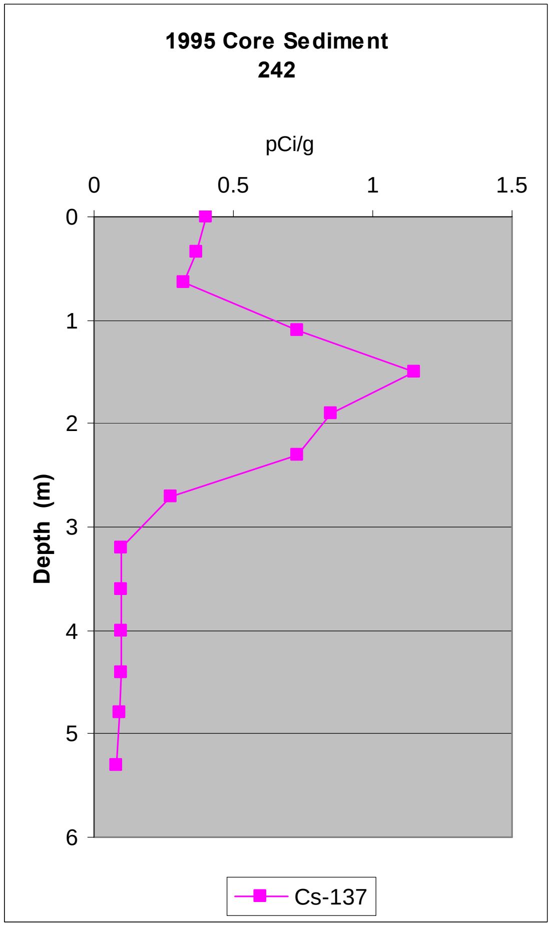
higher near-surface Cs^{137} concentration in core 240 (outer bend)





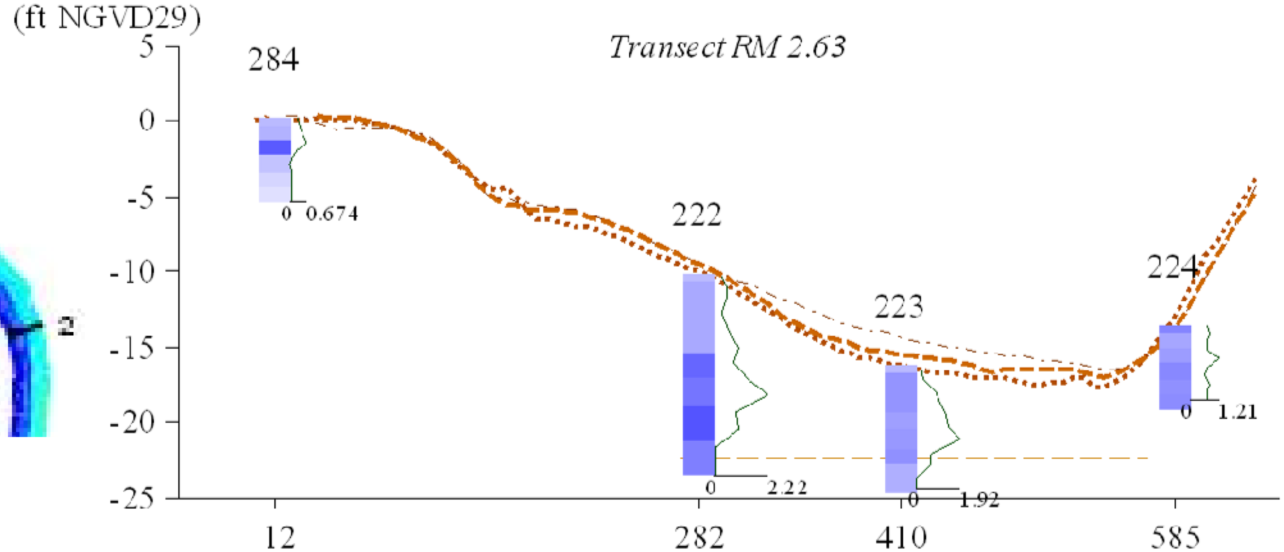


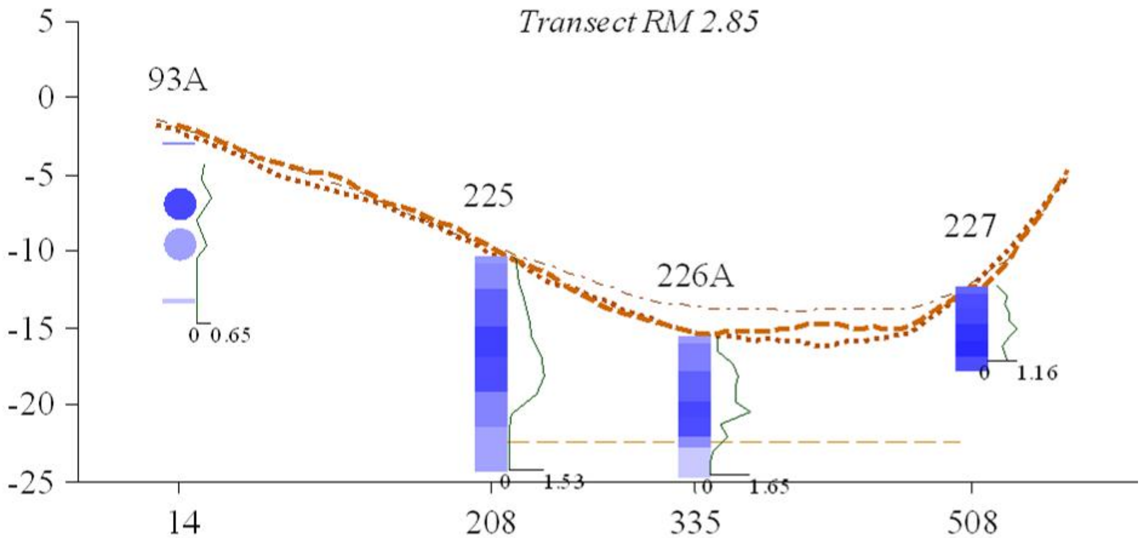
Observations from the 1995 cores

- the maximum Cs^{137} concentration in the outer bends is consistently closer to the bed surface than in the inner bends,

1995 Cs^{137} profiles – RM2.63 & RM2.85

computed skin friction





these pictures corroborate our observations

after Marcia Greenblatt

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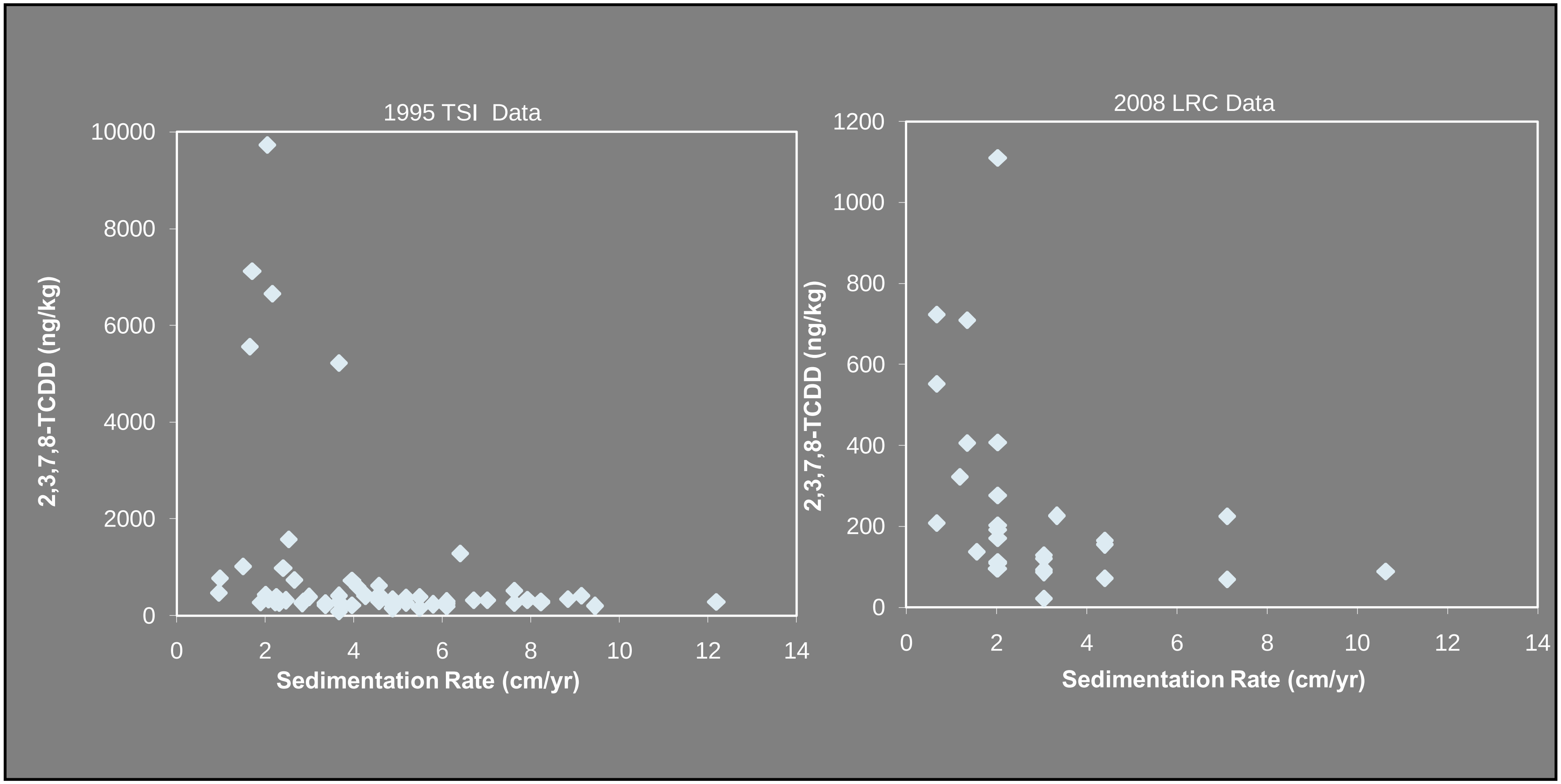
Observations from the 1995 cores

- the depth at which the maximum of the Cs^{137} profile is found is consistently shallower in the outer bends than in the inner bends,
- legacy sediments may be exposed in the outer bends of the main river channel, whereas they are buried deep within the riverbed elsewhere,

surface concentrations related to sedimentation rates

after Connolly, 2009 – note scales



historical sediments are buried

Observations from the 1995 cores

- the depth at which the maximum of the Cs^{137} profile is found is consistently shallower in the outer bends than in the inner bends,
- older sediments may become exposed in the outer bends of the main river channel, whereas they are buried elsewhere,
- understanding the observed sedimentary patterns requires understanding of the morphodynamics during the post-dredging period,
- our conceptual picture can only by quantified through modeling, including hindcasts,
- we need to compare 1995 and 2008 coring, and where possible include other core data as well.